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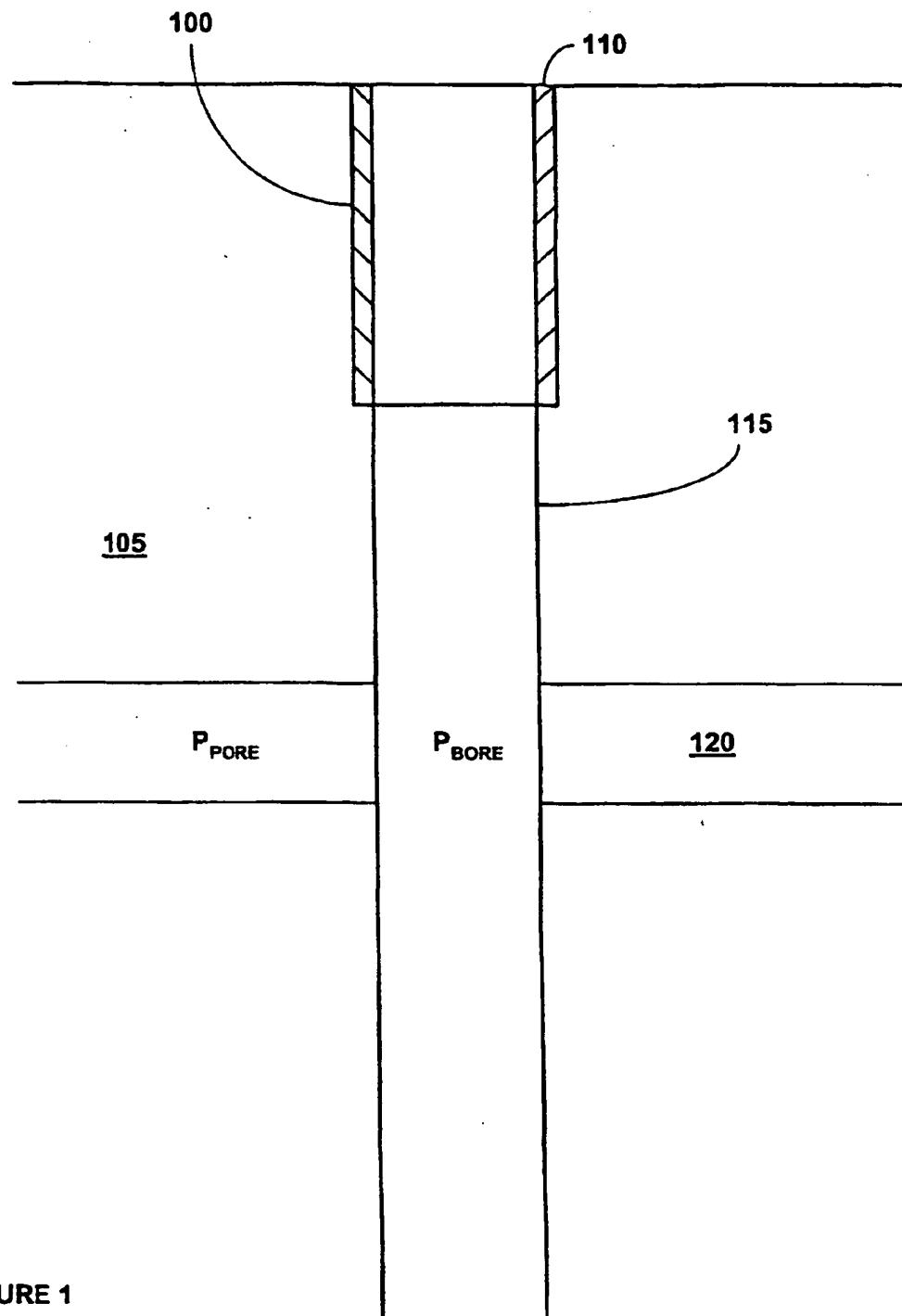


FIGURE 1

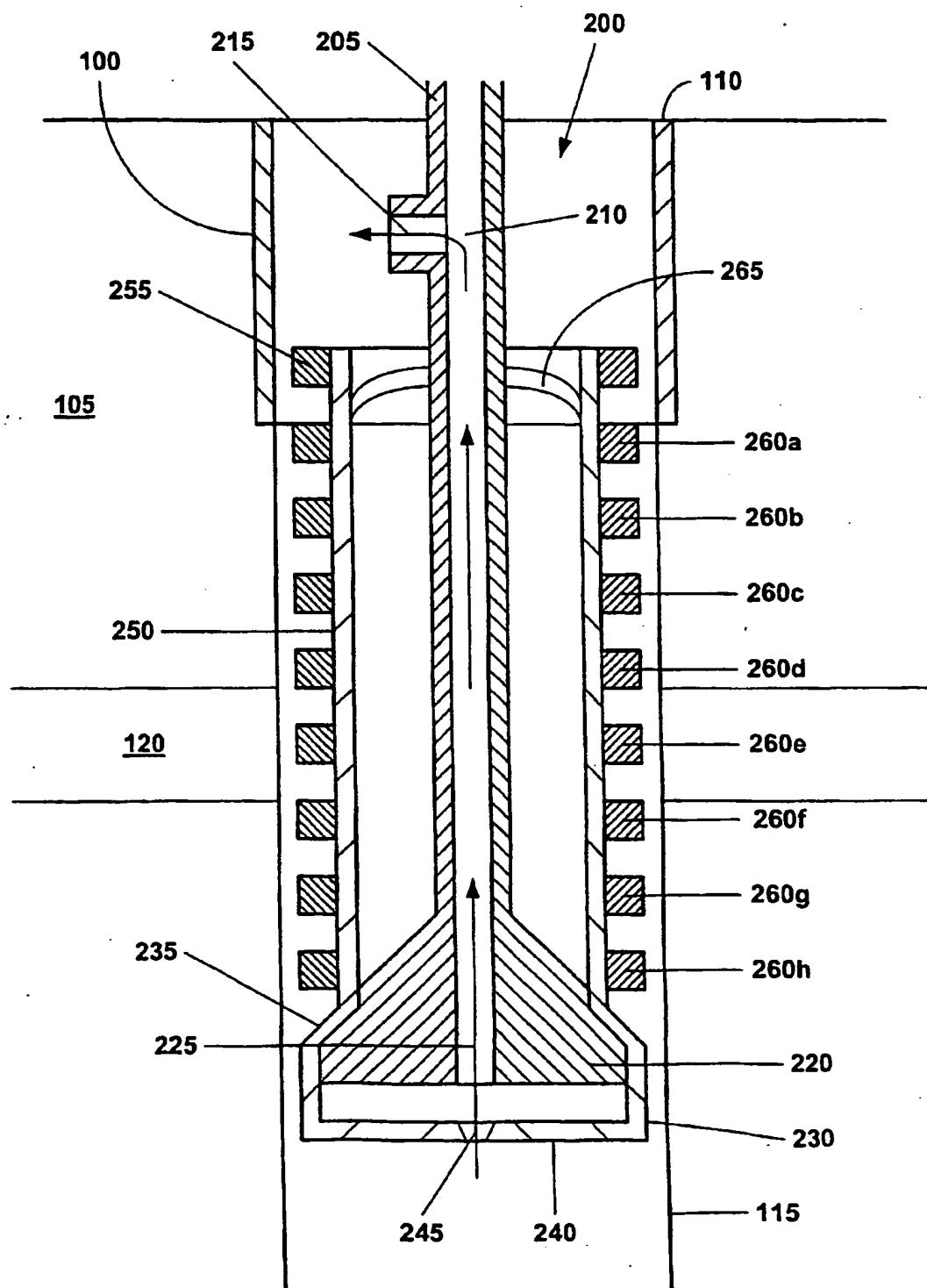


FIGURE 2

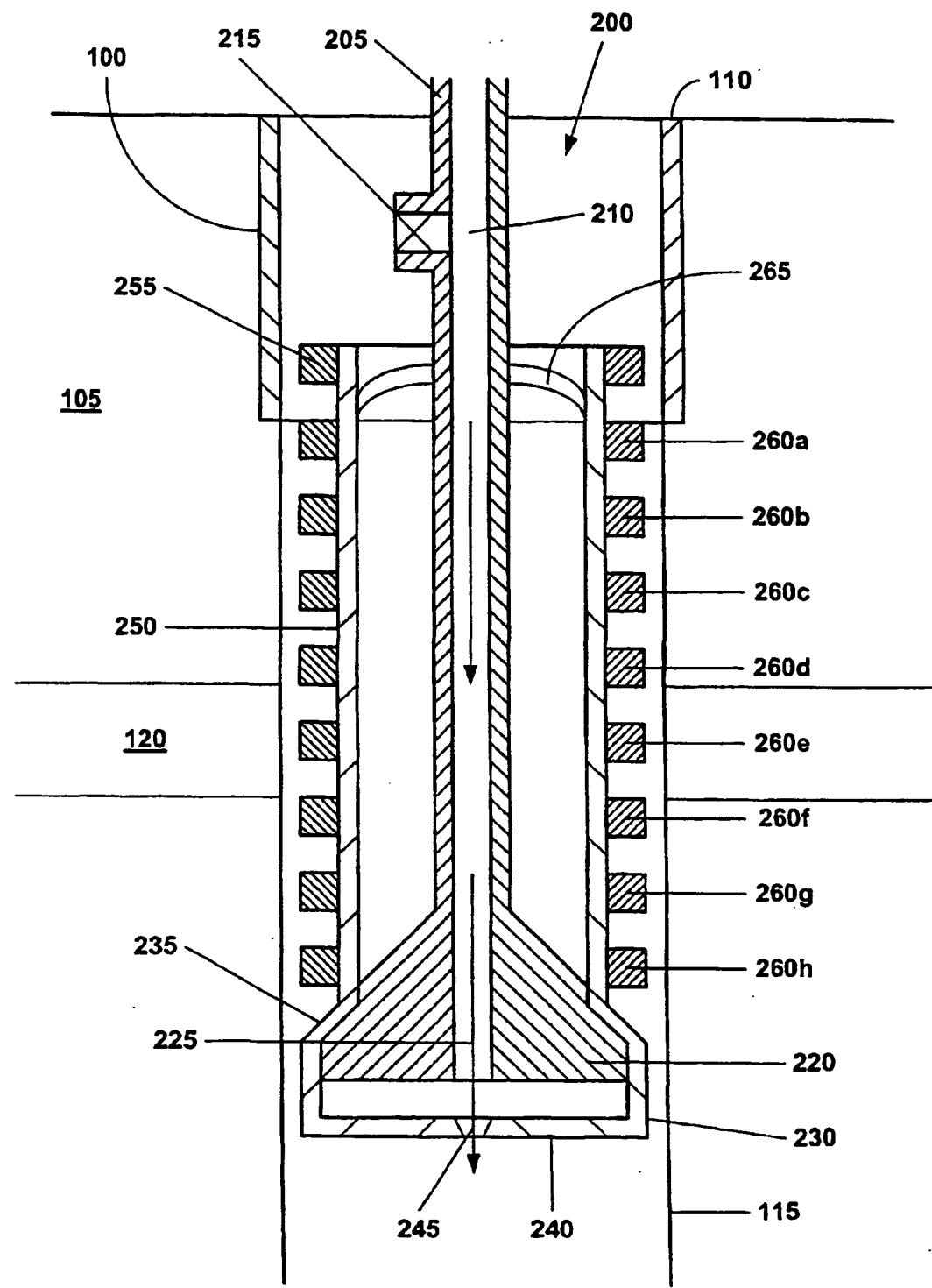


FIGURE 3

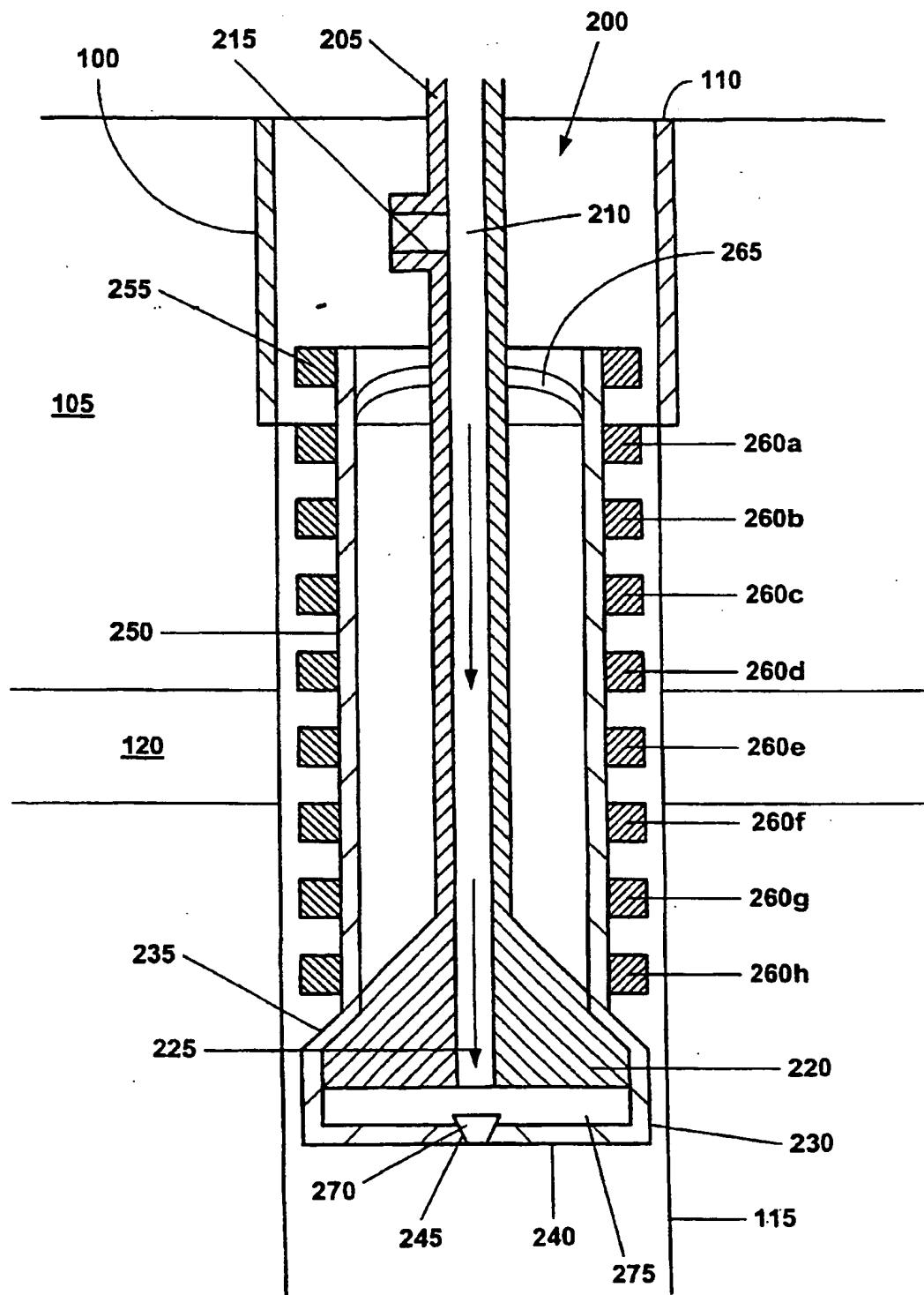


FIGURE 4

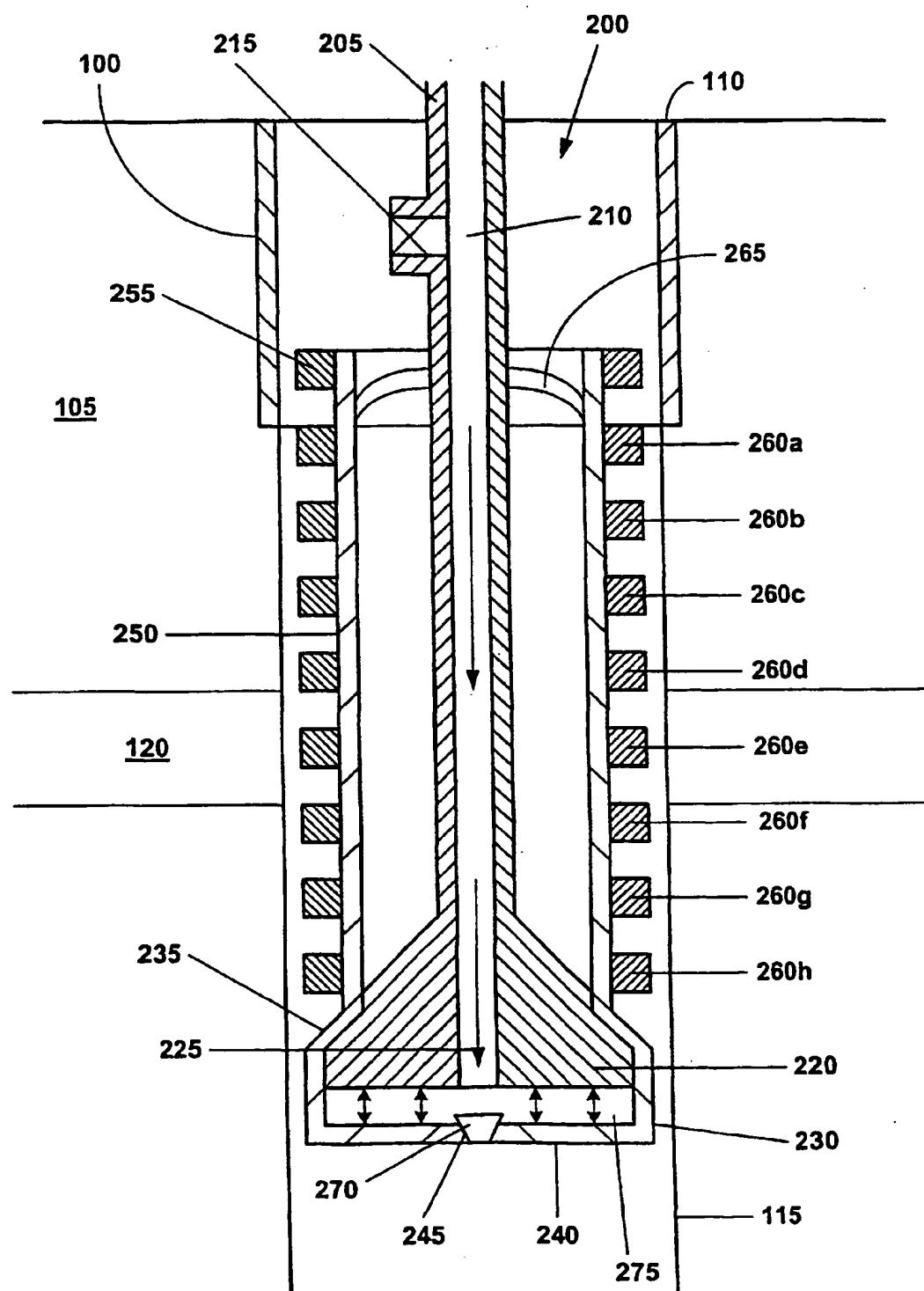


FIGURE 5

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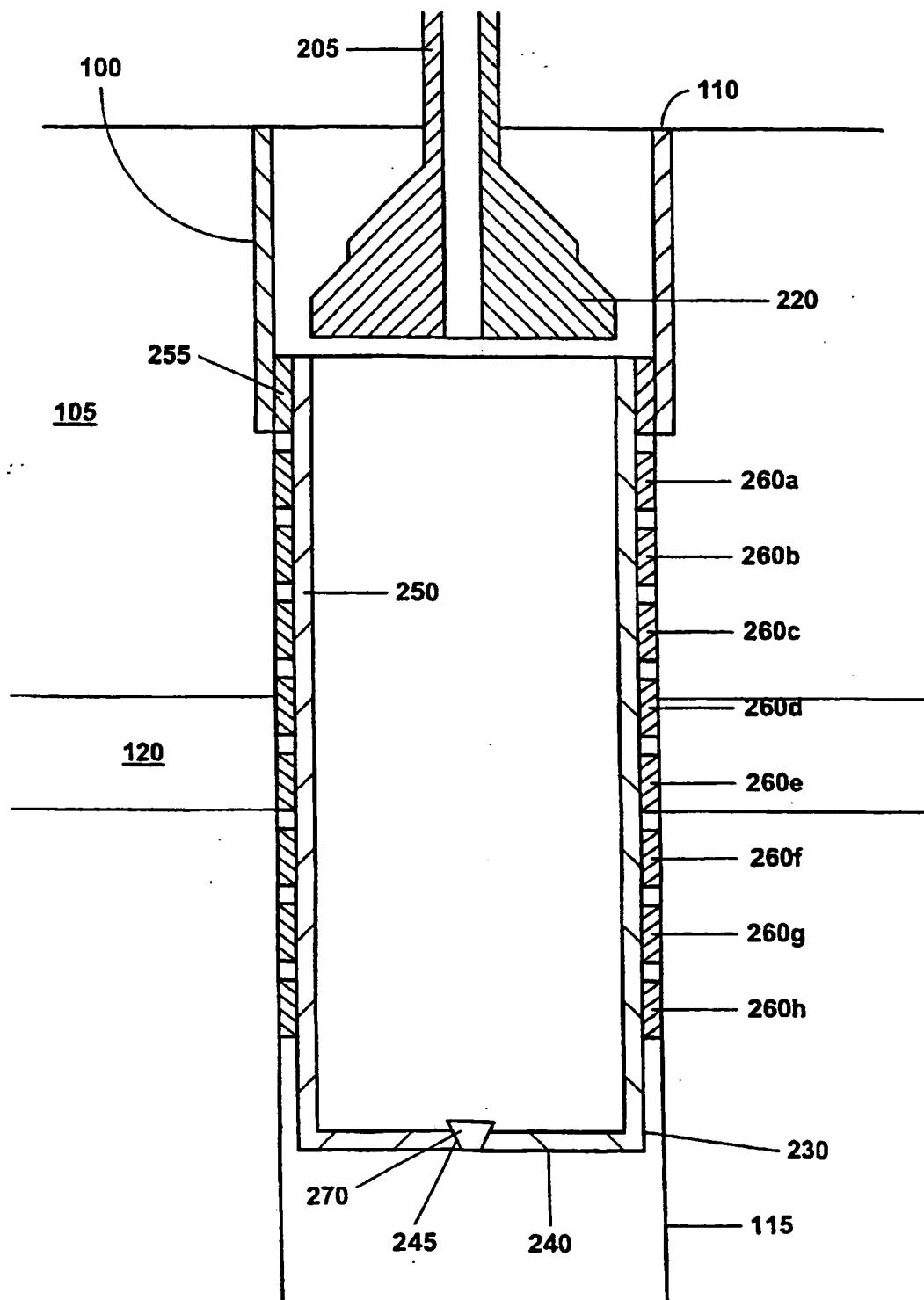


FIGURE 6

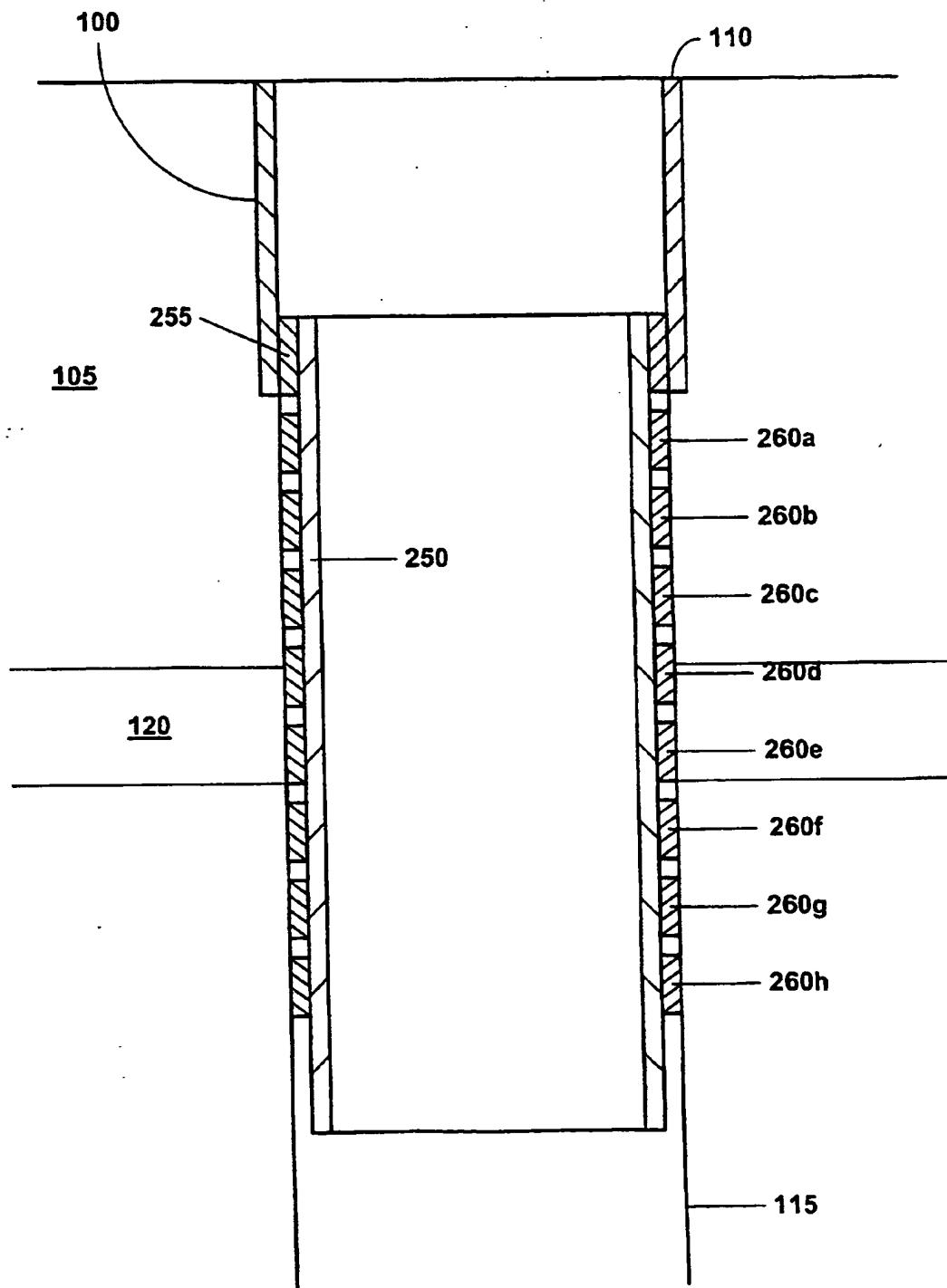


FIGURE 7

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COUPLING AN EXPANDABLE LINER TO A WELLBORE CASING

This invention relates to coupling an expandable liner to a wellbore casing.

- Conventionally, when a wellbore is created, a number of casings are installed in
- 5 the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of
- 10 smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such
- 15 a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and
- 20 removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores and wellheads.

Summary of the Invention

- 25 According to a first aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular
- 30 liner to the wellbore casing of the cased section of the wellbore, comprising:
positioning a solid tubular liner and an expansion cone within the wellbore;
overlapping a portion of the solid tubular liner with the wellbore casing;

radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

- 5 during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone proximate the porous subterranean zone.

According to a second aspect of the present invention there is provided in a wellbore that traverses a subterranean formation, the wellbore including a cased

- 10 section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:

- 15 positioning a solid tubular liner and an expansion cone within the wellbore;
overlapping a portion of the solid tubular liner with the wellbore casing;
radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and

- 20 during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

- According to a third aspect of the present invention there is provided in an An
apparatus for coupling a tubular liner to a wellbore casing within a wellbore that
25 traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone,
comprising:

- a tubular support member defining a first internal passage;
an expansion cone coupled to the tubular support member defining a second
30 internal passage fluidically coupled to the first internal passage;
a tubular expansion cone launcher movably coupled to and mating with the expansion cone;
a tubular liner coupled to an end of the tubular expansion cone launcher; and

a shoe coupled to another end of the tubular expansion cone launcher including a valveable passage; and

means for during a radial expansion of a portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal

- 5 stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore including a wellbore
10 casing and an open hole section that traverses a porous subterranean layer.

FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of an apparatus for casing the open hole section of the wellbore of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a fluidic material into the apparatus of FIG. 2.

15 FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a plug into the exhaust passage of the shoe of the apparatus of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the pressurization of the interior portion of the apparatus below the expansion cone of FIG. 4.

20 FIG. 6 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the tubular member of the apparatus of FIG. 5.

FIG. 7 is a fragmentary cross-sectional view illustrating the removal of the shoe from the apparatus of FIG. 6.

Detailed Description of the Illustrative Embodiments

An apparatus and method for casing an open hole section of a wellbore within
25 a subterranean formation is provided. The apparatus and method provides a system for casing an open hole section of a wellbore within a subterranean formation in which a tubular member having a plurality of radially oriented standoffs is radially expanded into contact with the preexisting wellbore casing and the open hole section. The standoffs provided on the exterior surface of the tubular member preferably position the
30 tubular member away from the interior walls of the open hole section during the radial expansion process. In this manner, the tubular member does not adhere to underpressurized sections of the open hole section of the wellbore. In this manner, the process of radial expansion is more reliable.

Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 and an open hole section 115 that traverses an porous region 120. When the operating pressure within the wellbore P_{BORE} is greater than the operating pressure within the porous region P_{PORE} , fluidic materials will flow from the wellbore 100 into the porous region 120. As a result of the flow of fluidic materials from the wellbore 100 into the porous region 120, downhole equipment will tend to adhere to, or at least be drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. This can have serious and adverse consequences when radially expanding a tubular member in such an

5 operating environment.

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Referring to Fig. 2, an apparatus 200 for forming a wellbore casing in the open hole section of the wellbore 100 may then be positioned within the wellbore in an overlapping relationship with the lower portion of the preexisting wellbore casing 110.

The apparatus 200 includes a tubular support member 205 having a

15 longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidically coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250

20 extends from the expansion cone launcher 230 that includes a sealing member 255 and a plurality of standoffs 260a-260h affixed to the exterior surface of the expandable tubular member. In a preferred embodiment, the standoffs 260 are fabricated from a resilient material. A sealing cup 265 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the

25 expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent 6,328,113 issued December 11, 2001, and filed as application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent

30 application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent 6,497,289, issued December 24, 2002, and filed as application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application

serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent

5 application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent 6,575,240 issued June 10, 2003, and filed as application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000,

10 which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on

15 3/11/1999, (7) U.S. patent 6,604,763, issued August 12, 2003, and filed as application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent 6,557,640, issued May 6, 2003, and filed as application serial number

20 09/588,946, attorney docket number 25791.17.02, filed on June 7, 2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203,

25 attorney docket number 25791.25, filed on 7/29/1999; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent 6,568,471 issued May 27, 2003, and filed as application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial

30 number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number 60/212,359, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional

patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on

5 11/12/1999.

As illustrated in Fig. 2, during placement of the apparatus 200 within the wellbore 100, fluidic materials displaced by the apparatus 200 are conveyed through the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore 100 are minimized. Furthermore, as illustrated in Fig. 2, the apparatus 200 is preferably initially positioned with upper portion of the tubular member 250 in opposing relation to the lower portion of the preexisting wellbore casing 110. In this manner, the upper portion of the tubular member 250 may be radially expanded into contact with the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the 10 placement of the apparatus 200 within the wellbore 100, the standoffs 260a-260h prevent the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the 15 apparatus 200 is approximately centered within the wellbore 100.

As illustrated in Fig. 3, the transverse passage 215 may then be closed and 20 fluidic materials injected into the apparatus 200 through the longitudinal passage 210. In this manner, any blockages within any of the passages 210, 225, and 245 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

25 As illustrated in Fig. 4, a plug 270 or other conventional stop member may then be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 270 may be positioned within the exhaust passage 245. In this manner, the exhaust passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby 30 pressurize a region 275 below the expansion cone 220.

As illustrated in Figs. 5 and 6, continued pressurization of the region 275 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper portion of the radially expanded

tubular member 250 is coupled to the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the radial expansion process, the tubular support member 205 is raised out of the wellbore 100.

- In a preferred embodiment, throughout the radial expansion process, the
- 5 standoffs 260a-260h prevent the exterior surface of the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is preferably substantially centered within the wellbore 100. Furthermore, in this manner, the longitudinal center axis of the expansion cone 220 is preferably maintained in a position that is
- 10 substantially coincident with the longitudinal center axis of the tubular member 250. In addition, in this manner, the stresses applied to the interior surface of the tubular member 250 by the axial displacement of the expansion cone 220 are substantially even. Finally, in this manner, overstressing of the tubular member 250 is prevented thereby eliminating catastrophic failure of the tubular member 250.

- 15 As illustrated in Fig. 7, the shoe 240 may then be removed using a conventional milling device.

- In a preferred embodiment, upon radially expanding the expandable tubular member 250, the standoffs 260a-260h seal and isolate intervals within the open hole section 115. In several alternative embodiments, the standoffs 260 may be provided,
- 20 for example, by annular members spaced along the length of the expandable tubular member 250 and/or a continuous member that is wrapped around the expandable tubular member 250 in helical fashion.

- It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the apparatus 200 may be used to form
- 25 and/or repair, for example, a wellbore casing, a pipeline, or a structural support.

- Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is
- 30 appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

1. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:
 - 5 positioning a solid tubular liner and an expansion cone within the wellbore;
 - 10 overlapping a portion of the solid tubular liner with the wellbore casing;
 - radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and
 - 15 during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone proximate the porous subterranean zone.
2. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:
 - 20 positioning a solid tubular liner and an expansion cone within the wellbore;
 - overlapping a portion of the solid tubular liner with the wellbore casing;
 - radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and
 - 25 during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

40 31 03

3. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:
 - 5 a tubular support member defining a first internal passage;
 - an expansion cone coupled to the tubular support member defining a second internal passage fluidically coupled to the first internal passage;
 - a tubular expansion cone launcher movably coupled to and mating with the expansion cone;
 - 10 a tubular liner coupled to an end of the tubular expansion cone launcher; and
 - a shoe coupled to another end of the tubular expansion cone launcher including a valveable passage; and
 - means for during a radial expansion of a portion of the solid tubular liner that
 - 15 does not overlap with the wellbore casing, preventing the application of unequal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

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